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(74) Agent: STARKWEATHER, Michael, W.; CTS Corporation, 905 West Boulevard North, Elkhart, IN 46514 (US).

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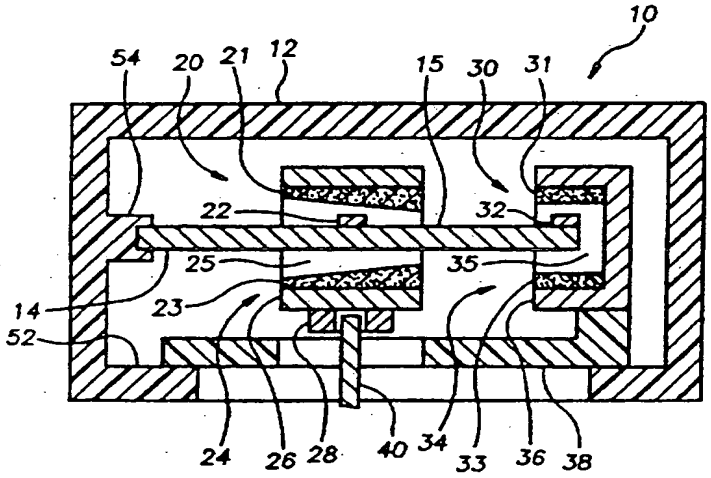
(54) Title: A TWO AXES LINEAR POSITION SENSOR



(57) Abstract

A dual-axes position sensor (10) having an outer housing (12), an actuator (40), a linear Hall effect sensor assembly (20) for detecting position changes along a first (y) axis, and a linear Hall effect sensor assembly (30) for detecting position changes along a second (x) axis is disclosed. The housing (12) is preferably made out of a non-magnetic material such as plastic. Actuator (40) is rod shaped and coupled to a movable device or shaft (not shown) that is to have its position sensed. The linear Hall effect sensor assembly (20) is unattachably positioned to set on lip (52) of the housing (12), and includes a magnetically conducting pole piece (26), a magnet assembly (24) comprising an upper magnet (21) and a lower magnet (23) that are separated by an air gap (25). Magnet assembly (24) and pole piece (26) are positioned around a Hall sensor device support (14) in a "U" shaped configuration or form. Hall sensor device support (14) is fixedly attached to housing (12) via attachment area (54). Linear Hall effect sensor assembly (20) also includes a positionally fixed Hall effect sensor element (22) attached to Hall sensor device support (14) on surface (15). Linear Hall effect sensor assembly (30) is positioned approximately 90 degrees from and to linear Hall effect sensor assembly (20).

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TITLE: A TWO AXES LINEAR POSITION SENSOR

BACKGROUND OF THE INVENTION

1. TECHNICAL FIELD

This invention relates to a Hall effect position sensor for determining linear position changes along two different axes. The sensor can be used for a variety of applications including a position sensor for a manual shifter.

2. BACKGROUND ART

In recent years, many designers of positional sensing equipment have been designing a new breed of sensors based upon the general theories of magnetics. For example, the automotive industry has been in the process of converting the control system of the standard internal combustion engine to a system that can be controlled by a computer that receives input signals from mechanical and electrical systems using hall effect positional sensors.

Examples of patents related to the present invention are as follows, and each patent is herein incorporated by reference for supporting teachings:

U.S. patent no. 5,369,361 is a position detecting device using a hall sensor. The device comprises a Hall IC, a magnet, and a back yoke. The Hall IC is moved in a space above the magnet, the position can be detected based upon the change in flux density between the poles of the magnet.

U.S. patent no. 5,365,791, is a signal generator for generating an electrical signal that varies according to movement of an actuating member includes a plunger slidable mounted within a housing that carries a pair of permanent magnets for generating a magnetic field to be applied to a Hall effect generator. U.S. patent no. 4,958,615, is a signal generator that has a Hall effect sensor and a magnet disposed inside a distributor housing.

U.S. patent no. 4,928,089, is an encoder for a wheel that uses a linear Hall effect sensor and magnet mounted on a non-ferrous metal shaft.

U.S. patent no. 4,703,261, is a measuring system for a gear measuring feeler that has a Hall effect sensor elements arranged in opposing relationship to each other in the magnetic field.

U.S. patent no. 3,473,109 is a position sensor utilizing a Hall generator. A pair of permanent magnets are co-planarly positioned with a pair of opposite poles abutting each other.

The foregoing patents reflect the state of the art of which the applicant is aware and are tendered with the view toward discharging applicant's acknowledged duty of candor in disclosing information that may be pertinent in the examination of this application. It is respectfully stipulated, however, that none of these patents teach or render obvious, singly or when considered in combination, applicant's claimed invention.

SUMMARY OF THE INVENTION

It is a feature of the invention to provide a Hall effect position sensor for determining linear position changes along two different axes.

An additional feature of the invention is to provide two Hall effect sensors. The first sensor detects any positional changes along the length of a first axis (y direction) of linear motion and a second sensor detects any positional changes along the length of a second axis (x direction) of linear motion.

The invention resides not in any one of these features per se, but rather in the particular combination of all of them herein disclosed and claimed, and it is distinguished from the prior art by this combination of structures for the functions specified.

There has thus been outlined, rather broadly, the more important features of the invention so the detailed description thereof that follows may be better understood, and so the present contribution to the art may be better appreciated. It is important, therefore, that the claims are regarded as including such equivalent constructions since they do not depart from the spirit and scope of the present invention.

The abstract is neither intended to define the invention of the application, which is measured by the claims, neither is it intended to be limiting as to the scope of the invention in any way.

Other features of the present invention will become more clear from the following detailed description of the invention, taken with the accompanying drawings and claims, or may be learned by the practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional view of an embodiment of the invention taken along line a-a of FIG. 2.

FIG. 2 is a sectional view of the embodiment of FIG. 1 with the housing removed.

FIG. 3 is an exploded perspective view of a preferred embodiment.

FIG. 4 is a cross sectional view of the preferred embodiment of FIG. 3.

It is noted that the drawings of the invention are not to scale. The drawings are merely schematic representations, not intended to portray specific parameters of the invention. The drawings are intended to depict only typical embodiments of the invention, and therefore should not be considered as limiting the scope of the invention. The invention will be described with additional specificity and detail by the accompanying drawings. In the drawings, like numbering represents like elements between the drawings.

DISCLOSURE OF THE INVENTION

The present invention provides a Hall effect position sensor for determining linear position changes along two different axes. Regarding **FIG. 1** and **FIG. 2**, there is a dual axes position sensor **10** having an outer housing **12**, an actuator **40**, a linear Hall effect sensor assembly **20** for detecting position changes along a first (y) axis, and a linear Hall effect sensor assembly **30** for

detecting position changes along a second (x) axis. The housing **12** is preferably made out of a non-magnetic material such as plastic. The actuator **40** is rod shaped and coupled to a movable device, body, or shaft (not shown) that is to have its position sensed. The linear Hall effect sensor assembly **20** is unattachably positioned to set on lip **52** of housing **12**, and includes a magnetically conducting pole piece **26**, a magnet assembly **24** that comprises an upper magnet **21** and a lower magnet **23** that are separated by an air gap **25**. Air gap **25** changes width along the length of pole piece **26** as the thickness of magnet assembly **24** varies. Magnet assembly **24** may be insert molded to pole piece **26** or molded separately and glued in place. Pole piece **26** is attached to a slide **28** which slidably sits on top of slide **38**. Slide **28** has a longitudinal slot **29** capable of receiving actuator **40** (scotch-yoke configuration). Magnets assembly **24** and pole piece **26** are positioned around a Hall sensor device support **14** in a "U" shaped configuration or form. Hall sensor device support **14** is fixedly attached to housing **12** via attachment area **54**. A positionally fixed Hall effect sensor element **22** attached to Hall device support **14** on surface **15**.

Linear Hall effect sensor assembly **30**, positioned approximately 90 degrees from linear Hall effect sensor assembly **20**, likewise includes a magnetically conductive pole piece **36** and a magnet assembly **34** that comprises an upper magnet **31** and a lower magnet **33** that are separated by an air gap **35**. Pole piece **36** is attached to a slide **38** which slidably sits on lip **52** of housing **12**. Slide **38** has a longitudinal slot **39** capable of receiving actuator **40** (scotch-yoke configuration). Magnets assembly **34** and pole piece **26** are positioned around the Hall sensor device support **14** in a "U" shaped configuration or form. A positionally fixed Hall effect sensor element **32** attached to Hall device support **14** on surface **15**.

In operation, the dual-axes position sensor **10** will sense linear positioning along two different axes (y and x) of a body (not shown) that is coupled to actuator **40**. In particular, when the body is moved in a direction perpendicular to slide **28**, linear Hall effect sensor assembly **20** will determine the exact

position of the body along the y-axis. The position detection is accomplished by actuator **40** pushing slide **28** and correspondingly both magnet assembly **24** and pole piece **26** in the same direction. As magnet assembly **24** is moved, the magnet thickness and magnetic flux density (B_x) surrounding Hall effect sensor element **22** varies and is detected. Hall effect sensor element **22** produces a voltage signal based on the magnetic flux density, and the voltage signal is then amplified to provide a measurable signal that can be monitored by a control module (not shown). When the actuator is only moved in a direction along the y-axis, there is no change in flux density detected by Hall effect sensor element **32** because the actuator moves along slot **39** and does not push slide **38**.

Alternatively, if actuator **40** is moved in a direction along the x-axis, linear Hall effect sensor assembly **30** will operate in a manner similar to linear Hall effect sensor assembly **20** in detecting position changes along the x-axis. Of course, if actuator **40** is moved along a vector that does not correspond exclusively to either the x or y axis, then linear Hall effect sensor assembly **20** will determine the y component of the vector, and linear Hall effect assembly **30** will determine the x component of the vector.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring to **FIG. 3**, there is an exploded perspective view of an exemplary application of the preferred embodiment of the invention for potentially sensing the position of a manual shift transmission (not shown). In addition to the previously discussed elements of the drawing, the dual-axes position sensor **10** includes lip **56** for slide (slide rack) **28** to traverse along. In this embodiment, slide **28** slidably sits on a lip **56** of housing **12** instead of on top of slide **38**. A connector **48** is shown for providing electrical connection from dual-axes position sensor **10** to a vehicle control module (not shown). Hall sensor device support **14** includes a substrate with electrical components mounted thereon. Housing **12** also includes a cover **16** and a retainer piece **44** to hold actuator **40** in place using shoulder **60**. Retainer piece **44** can be made from any suitable material

including metal or plastic. Gasket **46** is used in mounting dual-axes sensor **10** to a manual shift transmission (not shown).

In reference to **FIG. 4**, there is illustrated a cross sectional view of an exemplary application of the preferred embodiment depicted in **FIG. 3**. In **FIG. 4** the Hall sensor device support **14** is shown wire bonded **50** to connector **48**. This view further includes a transmission shift rod **64** that is located in a shift tower mechanism (not shown), and which is coupled to actuator **40** using a ball **66** and socket **62** configuration. Dual-axis position sensor **10** can monitor both the axial and rotational travel of the shift rod using this ball **62** and socket **66** coupling. If transmission shift rod is pushed in the y-axis direction, actuator **40** will also move in the y-axis direction and the movement will be detected by linear Hall effect sensor assembly **20**. Furthermore, if transmission shift rod **64** is rotated about its axis **68**, actuator **40** will move along the x-axis, and linear Hall effect sensor assembly **30** will detect the movement.

Remarks About the Preferred Embodiment

One of ordinary skill in the art of designing and using hall effect position detecting sensors will realize many advantages from using the preferred embodiment. As illustrated in FIG 4, it is possible to couple the actuator to a stick shift of a vehicle to sense the position of the stick shift in both the x and y axis. A skilled artisan will also realize that the hall sensors are fixed relative to the motion of the related combination of the two magnets and connecting pole piece. Additionally, it is well understood that the sensors are electrically coupled to appropriate circuitry for analyzing the positional signals generated therefrom.

I have received another fax from Scotland regarding the AMP Z-pack matter. It indicates an urgency and has copied both Jim Hufford and Ian Archer, but not you. I believe we need to talk sooner than later regarding this Z-pack AMP license initiation subject. I will be out of the office until Monday, October 28.

Could you be available for a short telephone call around 10 a.m.? If not, could you notify my secretary of an alternative time for us to discuss this matter.

Variations of the Preferred Embodiment

Although the illustrated embodiments discuss the arrangement of the two sensors relative to each other, one skilled in the art will realize that the preferred embodiment would work with most any arrangement. For example, the two sensors could be positionally switched or placed at different angles to one another. Additionally, although the preferred embodiment discusses the use of two magnets and one pole piece per sensor with the Hall effect sensor positioned therebetween, a skilled artisan could probably use most any known hall effect based sensor design. It is contemplated to design the sensor assembly so that the magnets are stationary and the actuator moves the Hall sensor devices **20** and **30** instead. Additionally, there are many other ways to vary the intensity of the magnetic flux field other than using magnets having different thicknesses. The magnets could be of uniform thickness but positionally slanted to create a variable air gap, or they can be magnetized to varying magnetic flux strengths along their length. The poles in the magnets can also be oriented in a number of different ways so that the Hall sensor device will be able to detect movement.

While the invention has been taught with specific reference to these embodiments, someone skilled in the art will recognize that changes can be made in form and detail without departing from the spirit and the scope of the invention. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the description. All changes that come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed and desired to be secured by Patent is:

1. A sensor for determining linear position of a movable body along two different axes, comprising:

a) a housing;

b) an actuator coupled to the movable body;

c) first linear sensing means, positioned within the housing and coupled to the actuator, for sensing the linear position of the actuator along a first axis; and

d) second linear sensing means, positioned within the housing and coupled to the actuator, for sensing the linear position of the actuator along a second axis being different from the first axis.

2. The sensor of claim 1, wherein the first linear sensing means includes a first magnet means and first pole piece slidably engaged with the actuator to move linearly with the actuator.

3. The sensor of claim 1, wherein the second linear sensing means includes a second magnet means and second pole piece slidably engaged with the actuator to move linearly with the actuator.

4. The sensor of claim 1, wherein the first linear sensor has a first slide having a slot for slidably engaging the first linear sensor to the actuator.

5. The sensor of claim 1, wherein the second linear sensor has a second slide having a slot for slidably engaging the second linear sensor to the actuator.

6. The sensor of claim 1, wherein the first and second linear sensors can detect axial and rotational travel of the movable body.

7. The sensor of claim 2, wherein the first pole piece forms a U-shape where the first magnet means includes first and second magnets that are placed upon opposite legs of the first pole piece forming a gap between the first and second magnets.

8. The sensor of claim 7, wherein the first linear sensor includes a first Hall effect sensing element positioned within the gap to sense magnetic flux changes indicative of relative position of the body.

9. The sensor of claim 3, wherein the second pole piece forms an U-shape where the second magnet means includes third and fourth magnets placed upon opposite legs of the second pole piece forming a void between the third and fourth magnets.

10. The sensor of claim 9, wherein the second linear sensor includes a second Hall effect sensing element positioned within the void to sense magnetic flux changes indicative of relative position of the body.

11. The sensor of claim 6, wherein the movable body is a shifter that is coupled to the actuator using a ball and socket connection.

12. A sensor for determining the linear position of a movable body along two different axes, comprising:

a) a housing being fixed in position against relative movement of a the body;

b) an actuator, positioned in the housing and coupled to the movable body for receiving reciprocating motion;

c) first linear sensing means, positioned within the housing and coupled to the actuator, for sensing the linear position of the actuator along a first axis wherein the first linear sensing means includes a first magnet means and first pole piece slidably engaged with the actuator to move with the linear position of the actuator;

d) second linear sensing means, positioned within the housing and coupled to the actuator, for sensing the linear position of the actuator along a second axis wherein the second linear sensing means includes a second magnet means and second pole piece slidably engaged with the actuator to move with the linear position of the actuator;

e) the first linear sensor having a first slide with a first slot thereon for slidably engaging the first linear sensor to the actuator; and

f) the second linear sensor having a second slide with a second slot thereon for slidably engaging the second linear sensor to the actuator.

13. The sensor of claim 12, wherein the first and second linear sensors can detect axial and rotational travel of the movable body that is coupled to the actuator.

14. The sensor of claim 13, wherein the movable body is a shifter that is coupled to the actuator.

15. The sensor of claim 12, wherein the first pole piece forms a U-shape, where the first magnet means includes first and second magnets that are placed upon opposite legs of the first pole piece forming a gap between therebetween.

16. The sensor of claim 15, wherein the first linear sensor includes a first Hall effect sensing element positioned within the gap to sense magnetic flux changes indicative of a relative position of the body.

17. The sensor of claim 12, wherein the second pole piece forms an U-shape where the second magnet means includes third and fourth magnets placed upon opposite legs of the second pole piece forming a void therebetween.

18. The sensor of claim 12, wherein the second linear sensor includes a second Hall effect sensing element positioned within the void to sense magnetic flux changes indicative of a relative position of the body.

19. A sensor for determining the linear position of a movable body along two different axes, comprising:

a) a housing being fixed in position against relative movement of a the body;

b) an actuator, positioned in the housing and coupled to the movable body for receiving reciprocating motion;

c) first linear sensing means, positioned within the housing and coupled to the actuator, for sensing the linear position of the actuator along a first axis wherein the first linear sensing means includes a first magnet means and first pole piece slidably engaged with the actuator to move with the linear motion of the actuator;

d) second linear sensing means, positioned within the housing and coupled to the actuator, for sensing the linear position of the actuator along a second axis wherein the second linear sensing means includes a second magnet means and second pole piece coupled to the actuator to move with the linear motion of the actuator;

e) the first linear sensor having a first slide with a first slot thereon for slidably engaging the first linear sensor to the actuator;

f) the second linear sensor having a second slide with a second slot for slidably engaging the second linear sensor to the actuator;

g) the first and second linear sensors having the ability to detect axial and rotational travel of the movable body that is coupled to the actuator, and the movable body is a shifter that is coupled to the actuator;

h) the first pole piece forming a U-shape, where the first magnet means includes first and second magnets that are placed upon opposite legs of the first pole piece forming a gap therebetween;

i) the first linear sensor including a first Hall effect sensing element positioned within the gap to sense magnetic flux changes indicative of a relative

position of the body;

j) the second pole piece forming an U-shape, where the second magnet means includes third and fourth magnets placed upon opposite legs of the second pole piece forming a void therebetween; and

k) the second linear sensor including a second Hall effect element positioned within the void to sense magnetic flux changes indicative of a relative position of the body.

FIG. 1

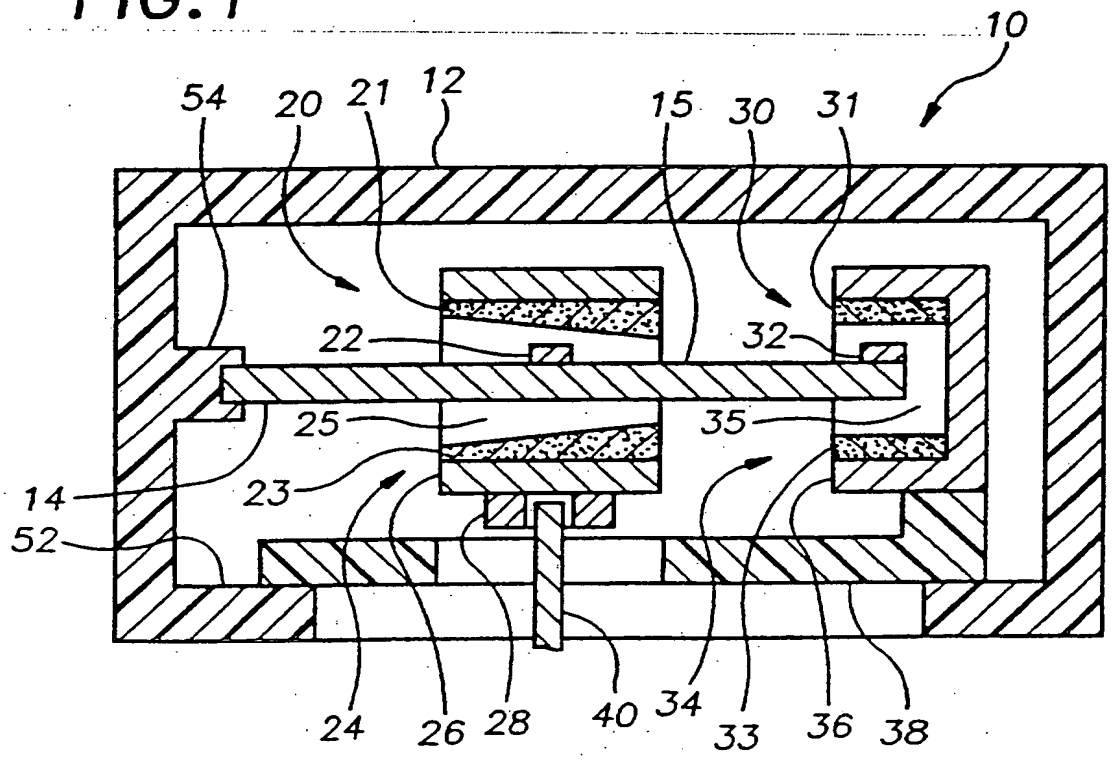


FIG. 2

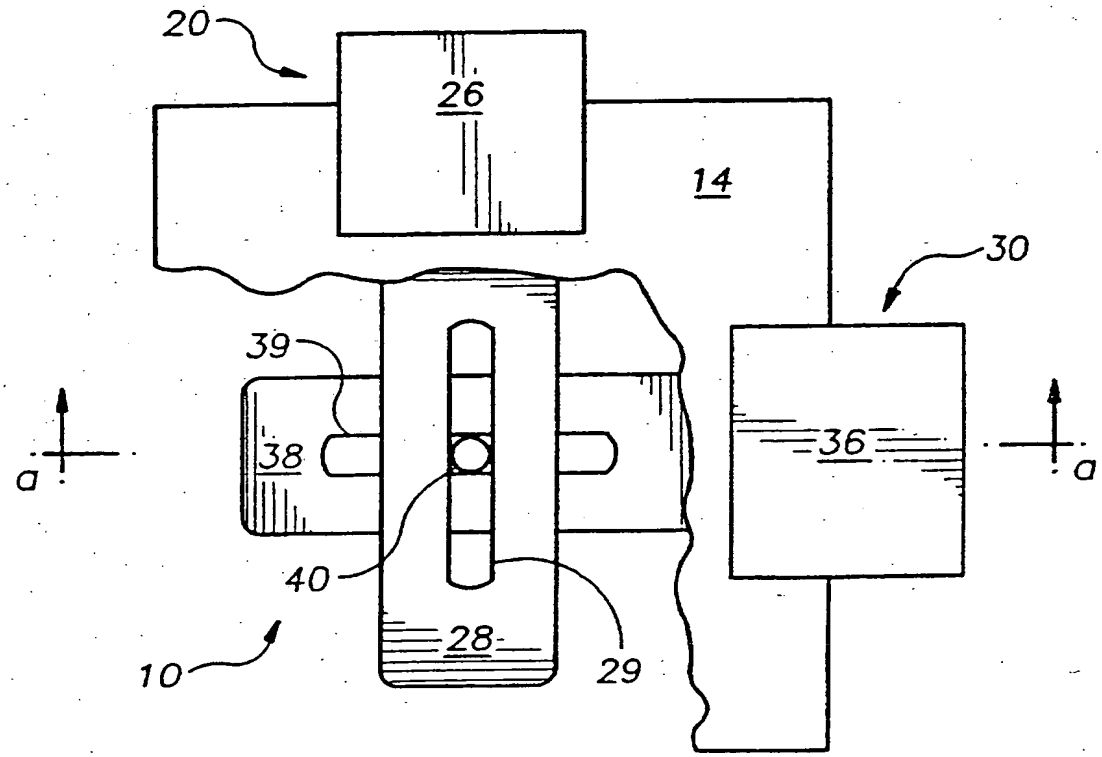


FIG.3

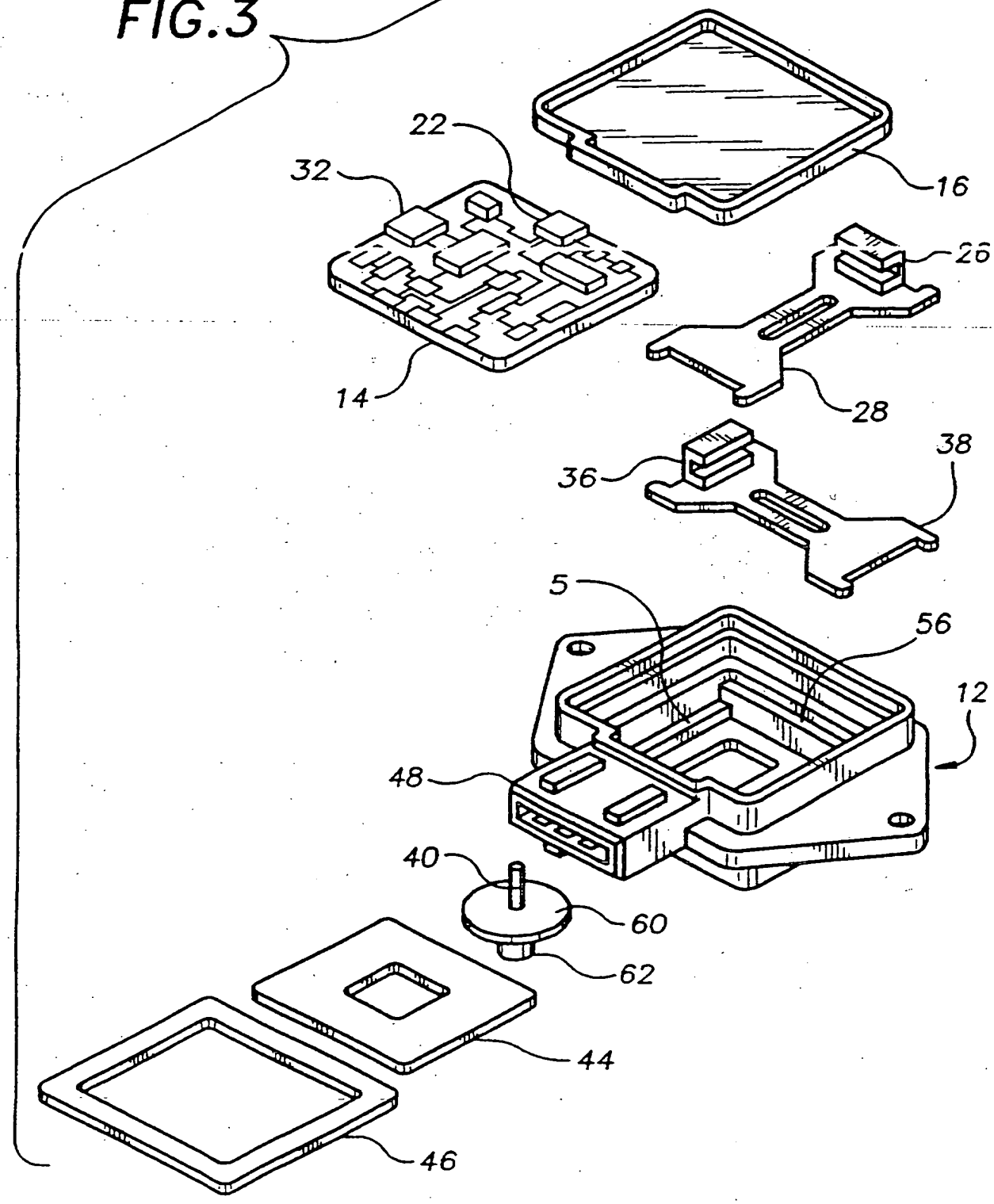
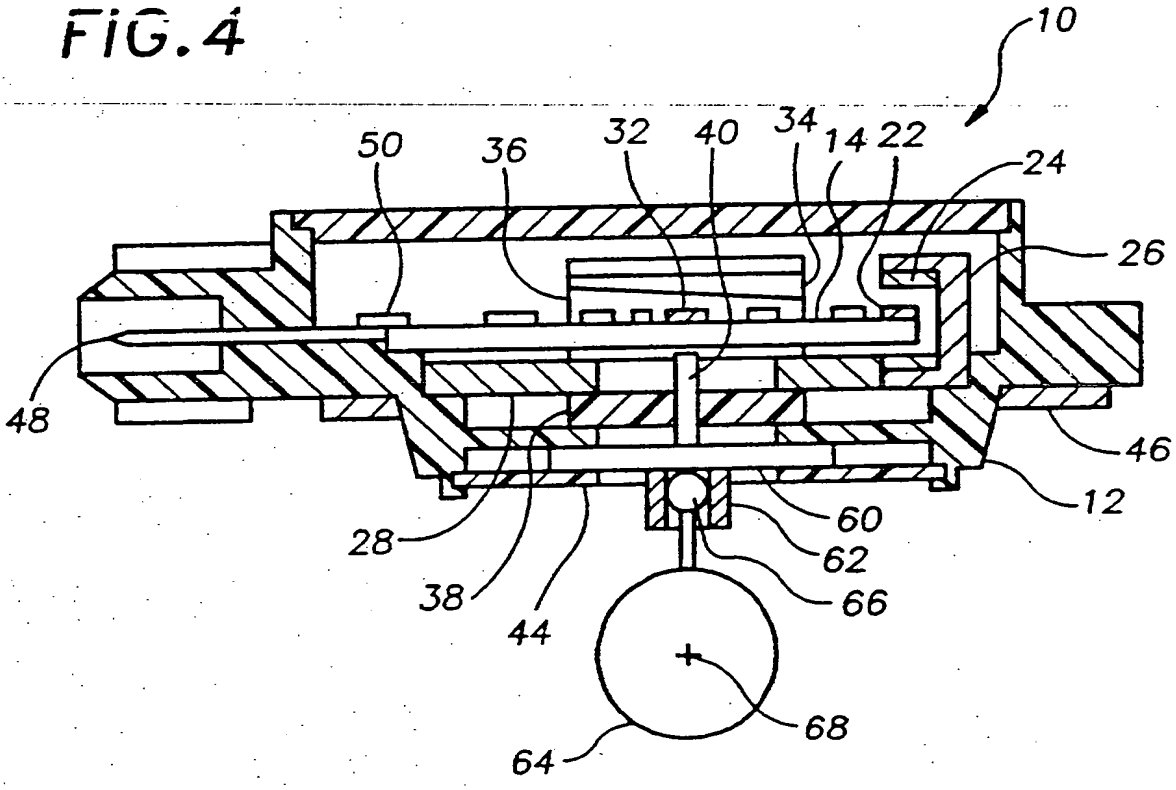


FIG. 4



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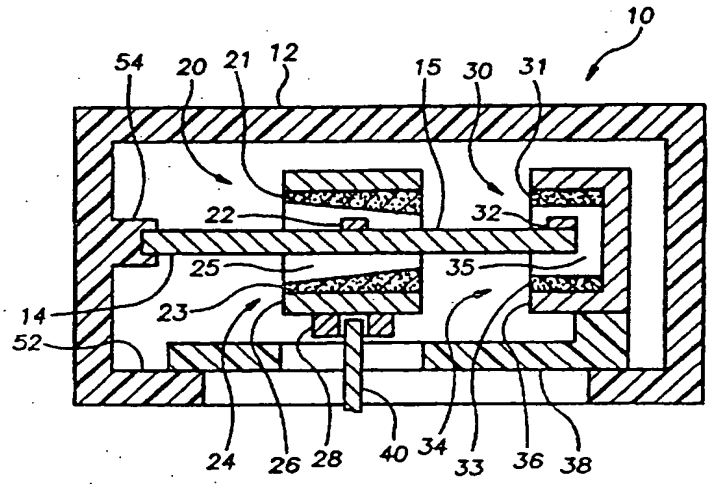

(57) Abstract

A dual-axes position sensor (10) having an outer housing (12), an actuator (40), two Hall effect sensor assemblys (20, 30) for detecting changes along a first (y) and second (x) axis is disclosed. The housing (12) is made of a non-magnetic material. The actuator (40) is rod shaped and coupled to a movable device. The Hall sensor assembly (20) is set on a lip (52) of the housing (12) and includes a pole piece (26) and a magnet assembly (24) having an upper and lower magnet (21, 23) seperated by an air gap (25). The two Hall sensor assemblies (20, 30) are positioned 90 degrees from each other.

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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 324/207.2,207.22,207.23,235,251;74/471XY;338/32H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3,421,227 A(TURNER et al.) 14 JANUARY 1969, col. 1,lines 26-70	1-19
A	US 4,639,667 A(ANDRESEN) 27 JANUARY 1987, Abstract	1-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 13 DECEMBER 1996	Date of mailing of the international search report 07 MAY 1997
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